# IBM 1401 Data Processing System
## Reference Card

## INSTRUCTION FORMAT

The IBM 1401 Data Processing System uses a variable word-length concept; the length of an instruction can vary from one to eight characters.

| OP CODE | A- or I-ADDRESS | B-ADDRESS | d-CHARACTER |
|---------|-----------------|-----------|-------------|
| X | XXX | XXX | X |

**Op Code:** This is always a single character which defines the basic operation being performed. A word mark is always associated with the operation code position of an instruction.

**A-Address:** This always consists of three characters. It can identify the units position of the A-field, or it can be used to select a special unit or feature (tape unit, column binary feature, disk storage, inquiry, etc.).

**I-Address:** Instructions that can cause program branches use the I-address to specify the location of the next instruction to be executed if a branch occurs.

**B-Address:** This is a three-character storage address associated with the B-field. It usually addresses the units position of the B-field, but in some operations, such as tape or disk record read and write, it specifies the high-order position of a record storage area.

**d-Character:** The d-character is used to modify an operation code. It is a single alphabetic, numerical, or special character, positioned as the last character of an instruction. It can be used with instructions of any length.

## PROCESSING OVERLAP

**A-Address**

The hundreds position of the A-address of a tape or input-output unit (not 1405 or 1407) instruction is changed from % to @. The symbol is used to signal an overlap operation with character reader, magnetic tape, paper tape, and data transmission units.

**Overlap Mode**

The following instructions are used when the system is in the overlap mode and card, printer or serial I/O operations are to be performed.

| INSTRUCTION | FUNCTION |
|-------------|----------|
| K$ | Overlap On |
| K(I)$ | Overlap On And Branch |
| K● | Overlap Off |
| K(I)● | Overlap Off And Branch |
| K□ | Reset Overlap |
| K(I)□ | Reset Overlap and Branch |

## 1405 TIMING

| TIMINGS (Model 2) | MAX. | AVG. | MIN. |
|-------------------|------|------|------|
| Disk to Disk | 800 ms | 600 ms | 450 ms |
| Track to Track | 250 ms | 175 ms | 100 ms |
| Record to Record, same Track | | 50 ms | 25 ms |

## SYSTEM TIMINGS

Key to abbreviations used in formulas

$L_A$ = Length of the A-field
$L_B$ = Length of the B-field
$L_O$ = Length of Multiplicand field
$L_I$ = Length of Instruction
$L_M$ = Length of Multiplier field
$L_Q$ = Length of Quotient field
$L_S$ = Length of Divisor field
$L_R$ = Number of significant digits in Divisor (Excludes high-order 0's and blanks)
$L_W$ = Length of A- or B-field, whichever is shorter
$L_X$ = Number of characters to be cleared
$L_Y$ = Number of characters back to right-most "0" in control field
$L_Z$ = Number of 0's inserted in a field
$I/O$ = Timing for Input or Output cycle
$F_m$ = Forms movement times. Allow 20 ms for first space, plus 5 ms for each additional space
$T_m$ = Tape movement times
$\Sigma$ = Number of fields included in an operation

### SYSTEM TIMINGS

| OPERATION | OP CODE | FORMULA |
|-----------|---------|---------|
| Punch a Card | 4 | $.0115\,(L_I + 1) + I/O$ |
| Read a Card | 1 | $.0115\,(L_I + 1) + I/O$ |
| Read and Punch | 5 | $.0115\,(L_I + 1) + I/O$ |
| Select Stacker | K | $.0115\,(L_I + 1)$ |
| Set Word Mark | , | $.0115\,(L_I + 1)$ |
| Start Punch Feed* | 9 | $.0115\,(L_I + 1)$ |
| Start Read Feed* | 8 | $.0115\,(L_I + 1)$ |
| Store A-address Register* | Q | $.0115\,(L_I + 5)$ |
| Store B-address Register* | H | $.0115\,(L_I + 4)$ |
| Subtract (no recomplement) | S | $.0115\,(L_I + 3 + L_A + L_B)$ |
| Subtract (recomplement) | S | $.0115\,(L_I + 3 + L_A + 4\,L_B)$ |
| Write a Line | 2 | $.0115\,(L_I + 1) + I/O$ |
| Write and Punch | 6 | $.0115\,(L_I + 1) + I/O$ |
| Write, Read and Punch | 7 | $.0115\,(L_I + 1) + I/O$ |
| Zero and Add | ? | $.0115\,(L_I + 1 + L_A + L_B)$ |
| Zero and Subtract | ! | $.0115\,(L_I + 1 + L_A + L_B)$ |

| OPERATION | OP CODE | FORMULA |
|-----------|---------|---------|
| Add (no recomplement) | A | $.0115\,(L_I + 3 + L_A + L_B)$ |
| Add (recomplement) | A | $.0115\,(L_I + 3 + L_A + 4\,L_B)$ |
| Branch | B | $.0115\,(L_I + 1)$ |
| Branch if Bit Equal* | W | $.0115\,(L_I + 2)$ |
| Branch if Character Equal | B | $.0115\,(L_I + 2)$ |
| Branch if Indicator On | B | $.0115\,(L_I + 1)$ |
| Branch if Word Mark and/or Zone | V | $.0115\,(L_I + 2)$ |
| Clear Storage | / | $.0115\,(L_I + 3)$ |
| Clear Word Mark | □ | $.0115\,(L_I + 1 + L_X)$ |
| Compare | C | $.0115\,(L_I + 1 + L_A + L_B)$ |
| Control Carriage | F | $.0115\,(L_I + 1) + F_m$ |
| Control Unit | U | $.0115\,(L_I + 1) + T_m$ |
| Divide (aver.)* | % | $.0115\,(L_I + 2 + 7\,L_R\,L_Q + 8\,L_Q)$ |
| Halt | . | $.0115\,(L_I + 1)$ |
| Load Characters to A Word Mark | L | $.0115\,(L_I + 1 + 2\,L_A)$ |
| Modify Address* | # | $.0115\,(L_I + 7 \text{ or } 9)$ |
| Move Characters to A or B Word Mark | M | $.0115\,(L_I + 1 + 2\,L_W)$ |
| Move Characters and Edit | E | $.0115\,(L_I + 1 + L_A + L_B + L_Y)$ |
| Move Characters to Record or Word Mark* | P | $.0115\,(L_I + 1 + 2\,L_A)$ |
| Move Characters and Suppress Zeros | Z | $.0115\,(L_I + 1 + 3\,L_A)$ |
| Move and Insert Zeros* | X | $.0115\,(L_I + 1 + 2\,\Sigma\,L_A + \Sigma\,L_Z)$ |
| Move Numeric | D | $.0115\,(L_I + 3)$ |
| Move Zone | Y | $.0115\,(L_I + 3)$ |
| Multiply (aver.)* | @ | $.0115\,(L_I + 3 + 2\,L_C + 5\,L_C\,L_M + 7\,L_M)$ |
| No Operation | N | $.0115\,(L_I + 1)$ |

* Special Feature

## TAPE OPERATIONS

$T_m$ — Tape movement can be determined from the following:
1 = Number of Characters
C = Character Rate

729 II at 200 cpi = .067 ms
at 556 cpi = .024 ms

729 V at 200 cpi = .067 ms
at 556 cpi = .024 ms
at 800 cpi = .017 ms

729 IV at 200 cpi = .044 ms
at 556 cpi = .016 ms

7330 at 200 cpi = .139 ms
at 556 cpi = .050 ms

729 Model II and V    Read 10.7 + CN ms = TAU interlocked
10.5 + CN ms = Processing interlocked
Write 11.7 + CN ms = Processing interlocked
7.5 + CN ms = Processing interlocked

729 Model IV,    Read 6.8 + CN ms = TAU interlocked
6.7 + CN ms = Processing interlocked
Write 7.8 + CN ms = TAU interlocked
5 + CN ms = Processing interlocked

7330    Read 20.5 + CN ms = TAU interlocked
7.7 + CN ms = Processing interlocked
Write 20.3 + CN ms = TAU interlocked
5 + CN ms = Processing interlocked

Rewind
729 Models II and V = 1.2 minutes/reel
729 Model IV = .9 minutes/reel
7330 (High Speed) = 2.2 minutes/reel

Skip and Blank Tape
(add to subsequent write time)
729 Models II and V = 40.5 ms
729 Model IV = 27 ms
7330 = 103 ms

Backspace (after Read)
729 Models II and V = 46 + CN ms
729 Model IV = 33 + CN ms
7330 = 428 + CN ms

Backspace (after Write)
729 Models II and V = 52 + CN ms
729 Model IV = 37 + CN ms
7330 = 435 + CN ms

## INPUT-OUTPUT CODES

| OPERATION CODE | FUNCTION | MNEMONIC | BCD CODE | CARD CODE |
|---|---|---|---|---|
| 1 | Read a Card | R | 1 | 1 |
| 2 | Write a Line | W | 2 | 2 |
| 2 □ | Write Word Marks | | □ is modifier | |
| 3 | Write-Read | WR | C21 | 3 |
| 4 | Punch a Card | P | 4 | 4 |
| 4R | Read-Punch Feed* | | R is modifier | R is modifier |
| 4(I)R | Read-Punch Feed and Branch* | | R is modifier | R is modifier |
| 5 | Read-Punch | RP | C41 | 5 |
| 6 | Write-Punch | WP | C42 | 6 |
| 6R | Write-Read Punch Feed* | | R is modifier | R is modifier |
| 6(I)R | Write-Read Punch Feed and Branch* | | R is modifier | R is modifier |
| 7 | Write-Read-Punch | WRP | 421 | 7 |
| 8 | Start Read Feed* | SRF | 8 | 8 |
| 9 | Start Punch Feed* | SPF | C81 | 9 |

## ARITHMETIC CODES

| OPERATION CODE | FUNCTION | MNEMONIC | BCD CODE | CARD CODE |
|---|---|---|---|---|
| A | Add | A | BA1 | 12-1 |
| S | Subtract | S | CA2 | 0-2 |
| ? | Zero and Add | ZA | CBA82 | 12-0 |
| ! | Zero and Subtract | ZS | B82 | 11-0 |
| @ | Multiply* | M | C84 | 4-8 |
| % | Divide* | D | A84 | 0-4-8 |

## LOGIC OPERATION CODES

| OPERATION CODE | FUNCTION | MNEMONIC | BCD CODE | CARD CODE |
|---|---|---|---|---|
| B(I) | Branch | B | BA2 | 12-2 |
| B(I)d | Branch if Indicator ON | | d is modifier | d is modifier |
| B(I)(B)d | Branch if Character is Equal | | Contents of B compared to d | |
| V(I)(B)d | Branch if WM and/or Zone | BWZ | A41 | 0-5 |

## MOVE AND LOAD CODES

| OPERATION CODE | FUNCTION | MNEMONIC | BCD CODE | CARD CODE |
|---|---|---|---|---|
| D | Move Numerical | MN | BA4 | 12-4 |
| L | Load Character to A Word Mark | LCA | B21 | 11-3 |
| M | Move Characters to A or B Word Mark | MCW | CB4 | 11-4 |
| Y | Move Zone | MZ | CA8 | 0-8 |
| Z | Move Characters and Suppress Zeros | MCS | A81 | 0-9 |
| ? | Set Word Mark | SW | CA821 | 0-3-8 |
| □ | Clear Word Mark | CW | CBA84 | 12-4-8 |

## MISCELLANEOUS OPERATION CODES

| OPERATION CODE | FUNCTION | MNEMONIC | BCD CODE | CARD CODE |
|---|---|---|---|---|
| C | Compare | C | CBA21 | 12-3 |
| E | Move Characters and Edit | MCE | CBA41 | 12-5 |
| F | Control Carriage | CC | CBA42 | 12-6 |
| H | Store B-Address Register* | SBR | BA8 | 12-8 |
| K | Select Stacker | SS | CB2 | 11-2 |
| N | No Operation | NOP | B41 | 11-5 |
| Q | Store A-Address Register* | SAR | CB8 | 11-8 |
| / | Clear Storage | CS | CA1 | 0-1 |
| • | Halt | H | BA821 | 12-3-8 |
| # | Modify Address* | MA | 821 | 3-8 |

## CHARACTER AT d FOR B(I)d BRANCH

| d | BRANCH ON | d | BRANCH ON |
|---|---|---|---|
| b1 | Unconditional | R | Carriage Busy* |
| 9 | Carr. Chan. #9 | T | Low Compare B < A* |
| A | "Last Card" Switch | U | High Compare B > A* |
| B | Sense Switch B* | Z | Overflow |
| C | Sense Switch C* | ? | Reader Error if I/O Check Stop Switch OFF |
| D | Sense Switch D* | ! | Punch Error if I/O Check Stop Switch OFF |
| E | Sense Switch E* | ≠ | Printer Error if I/O Check Stop Switch OFF |
| F | Sense Switch F* | @ | Carr. Chan. #12 |
| G | Sense Switch G* | % | Processing Check with Process Check Switch OFF |
| K | End of Reel* | / | Unequal Compare B ≠ A |
| L | Tape Error* | | |
| S | Equal Compare B = A* | | |
| P | Printer Busy* | | |

## CHARACTER AT d FOR MAGNETIC TAPE

| d | OPERATION |
|---|---|
| B | Backspace Tape Record |
| E | Skip and Blank Tape |
| M | Write Tape Mark |
| R | Rewind Tape |
| U | Rewind Tape and Unload |

## CHARACTER AT d FOR 1407 CONSOLE INQUIRY STATION

| d | | |
|---|---|---|
| Q | Inquiry Request | * Inquiry Clear |

## MAGNETIC TAPE %UX TAPE UNIT ADDRESS

| INSTRUCTION | FUNCTION | MNEMONIC | BCD CODE | CARD CODE | REMARKS |
|---|---|---|---|---|---|
| L(%UX)(B)d | Read/Write Tape with Word Marks | LCA | | | d-modifier, R-Read Tape |
| M(%UX)(B)d | Read/Write Tape | MCW | | | W-Write Tape |
| M(%CX)(B)R | Read Compressed Tape* | | | | (%CX) is address of tape unit |
| P(A)(B) | Move Characters to Record or Group Mark* | MCM | CB421 | 11-7 | |
| U(%UX)d | Control Unit | CU | CA4 | 0-4 | |
| X(A)(B) | Move and Insert Zeros* | MIZ | CA421 | 0-7 | |

## COLUMN BINARY

| INSTRUCTION | FUNCTION | | REMARKS |
|---|---|---|---|
| 1C | Read Column Binary | | C is Modifier |
| 4C | Punch Column Binary | | C is Modifier |
| M(A)(B)A | Move and Binary Decode | | A is Modifier |
| M(A)(B)B | Move Binary Code | | B is Modifier |
| M(%BX)(A)R | Read Binary Tape | | %BX is Address of tape unit |
| M(%BX)(A)W | Write Binary Tape | | |
| W(I)(B)d | Branch if Bit Equal | | BBE is mnemonic |

## DISK STORAGE %FX DISK OPERATION

| INSTRUCTION | FUNCTION | | REMARKS |
|---|---|---|---|
| M(%F0)(B)R | Seek Disk | | B is Disk Address |
| M(%FX)(B)R | Read Disk | | X can be 1, 2, or 3 |
| M(%FX)(B)W | Write Disk | | 1 Specifies Single Record |
| L(%FX)(B)R | Read Disk with Word Marks | | 2 Specifies Full Track |
| L(%FX)(B)W | Write Disk with Word Marks | | 3 Specifies a Write Disk Check operation M(%F3)(B)W |

## CHARACTER AT d FOR DISK STORAGE

| d | BRANCH ON |
|---|---|
| N | Access Inoperable |
| V | Read/Write Parity Check or Read Back Check Error |
| W | Wrong-Length Record |
| X | Unequal Address Compare |
| Y | Any Disk Storage Error Condition |

## 1407 INQUIRY %TO ADDRESS

| INSTRUCTION | FUNCTION | | REMARKS |
|---|---|---|---|
| M(%TO)(B)R | Read Console Printer | | Data from 1407 transferred to B-address |
| M(%TO)(B)W | Write Console Printer | | Data at B-address transferred to 1407 |
| L(%TO)(B)R | Read Console Printer with Word Marks | | Data from 1407 transferred to B-address with Word Marks |
| L(%TO)(B)W | Write Console Printer with Word Marks | | Data at B-address transferred to 1407 with Word Marks |
| M(%TO)(B)W | Line Space | | B is address of a Group Mark with a Word Mark |

* Special Feature